ON THE OLD AND NEW LABORATORIES AT THE ROYAL INSTITUTION*

II.

OF the next great name connected with our Institution, namely, Michael Faraday, of his life and his discoveries the history has been already written, so far indeed as it can be written, by Bence Jones, by Tyndall, and by Gladstone. *Si monumentum quæris circumspice.* These volumes of notes, from 1831 to 1856, will give some idea of the amount of work which he did in our laboratory; and their value will be better appreciated through the consideration that before these notes were made, no less than sixty of his scientific papers had been printed, nine of them in the "Philosophical Transactions"

Those of us who were present at Tyndall's two memorable lectures on "Faraday as a discoverer" are not likely to forget the impression of the man left by them on our minds; and for those who were not present it would be an office thankless to your lecturer and burdensome to his hearers, to contribute a feeble reproduction of those life-like memoirs, For our present purpose it will be sufficient to say that the entire fabric of those brilliant and manifold contributions to human knowledge was wrought out within the walls of the Royal Institution.

His great experiments have been so often and so well exhibited in this theatre, that some apology is needed for bringing any of them before you again; but in repeating for my own instruction some of those which bear more particularly upon the subject of Light, I have been tempted to reproduce one of them here. In doing this I I have been perhaps moved more by a fascination of the phenomenon, and by a piece of instrumental good fortune which enables me to introduce an old friend under a new garb, than by any better reason. The experiment in question is that which Faraday called "the magnetisation of light, and the illumination of the lines of magnetic force;" we should now term it the rotation of the plane of polarisation under the influence of the magnetic field. And in order that we may not even by inadvertence confuse the rotation here produced with that due to quartz, or oil of turpentine, I will draw your attention, by way of memorandum, to the nature of the magnetism produced by spiral currents in given directions, and of the rotations of free currents produced by magnets.

[The lecturer then showed the opposite rotations of two sparks discharged about the two poles respectively of an electro-magnet, and the reversal of those rotations, first by a change of the poles, and secondly by a reversal of the direction of the sparks.]

You now see upon the screen an image of the figures produced by a magnificent piece of heavy glass under the action of polarised light. Its size enables me to make use of about four times the amount of light usually available in this experiment; and I have taken advantage of the figure which its imperfect annealing produces, to vary the effect upon the screen. The dark parts of the figure indicate the parts of the beam in which the vibrations are perpendicular to those transmitted by either polariser or analyser, and which are consequently cut off. Now if anything should intervene to change the plane of those vibrations a portion of them will be transmitted, and a partial illumination of the screen will ensue. This turning of the plane of vibration is effected by the magnet as soon as its force is developed by the electric current sent through its coils.

[The lecturer then "dispersed" the dark lines of the figure by means of a plate of quartz; and after turning polariser and analyser so as to colour the centre of the field with the tint intermediate between red and violet (*teinte sensible*), he showed that when the magnet was excited the field was rendered red or green according to the direction of the poles.]

Professor Frankland before coming to us had isolated the compound radicals Methyl, Ethyl, and Amyl, and had proved their resemblance to Hydrogen. He had also combined them with the metals zinc, tin, mercury, and boron. By this means he had obtained a very powerful chemical reagent, which proved of eminent service in subsequent operations. An instance of its power will be found in zinc-ethyl, which by its rapid combination with oxygen of the air, bursts into spontaneous combustion as soon as a flask containing it is opened.

In conjunction with Mr. Duppa, Prof. Frankland worked in our laboratory at the artificial formation of ethers. They treated acetic ether with iodine and with the iodides of methyl, ethyl, and amyl; and by their means they arrived at a method for the formation of many organic substances which had previously been obtained only through the agency of animals or of vegetables.

In 1866 Dr. Frankland determined by a long series of calorimetric experiments the maximum amount of force capable of being developed by given weights of the different foods commonly used by men.

In the following year he investigated the effect of pressure (up to 20 atmospheres) upon the luminosity of flames of hydrogen and of carbonic oxides. He found that these flames, so feebly luminous at ordinary atmospheric pressure, burn with brilliant light under pressures of from 10 to 20 atmospheres, and that the spectra of these brilliant flames are perfectly continuous. From the latter circumstance he infers that solar light may be derived from glowing gas and not from incandescent solid or liquid matter.

As these researches have so important a bearing upon spectral analysis and solar physics, I will venture to repeat one or two of the experiments. Here are three closed tubes filled respectively with hydrogen, oxygen, and chlorine, at atmospheric pressure. The densities of these substances are in the proportions $1 : 16 : 35\frac{1}{2}$; and if the spark from an induction coil be made to pass through them, the luminosity of the discharge will be found to be nearly in the same proportions. That this result is really due to the density, and not to the chemical constitution of the gases, may be proved by allowing the discharge to pass through this tube, and by pumping air into it during the discharge. It will then be seen that the brilliancy increases with the pressure.

These researches were suggested by an old experiment of Cavendish's, in which he exploded a mixture of oxygen and hydrogen, first under atmospheric pressure and then under a pressure of from 10 to 12 atmospheres. In the first case there is much noise and little light; in the second, a brilliant flash and no noise. The labours of Dr. Frankland have rendered this experiment intelligible, and have correlated it with other phenomena.

Of Dr. Frankland's successor, Dr. Odling, I should have had more to say, had he not been attracted by a well-deserved offer of the chemical chair at Oxford. As a member of that University I rejoice at the appointment, while here we regret the loss.

Of Faraday's successor, John Tyndall, I am greatly at a loss how to speak. In this place his presence seems so near to us, his thoughts so subtle, his words—even when rung back to us from those busy cities far away on the other side of the Atlantic—so familiar and yet so stirring, that it behoves us that ours should be wary and few. Few men have brought so large a burden and bulk of contribution to the common stock of knowledge; but still fewer have inspired in his hearers so strong a love, such ardent enthusiasm for the subjects of his research.

It is now twenty years since Prof. Tyndall began his researches in our laboratory. During the first thirteen years he produced no less than thirteen papers, which were printed in the "Philosophical Transactions:" on Sound, on Diamagnetism, on Glaciers and Ice, on the

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* Continued from p. 224.

Radiation and Absorption of Heat, and on Calorescence. In these he established the important fact that if the various gases be arranged in order according to their power, first of radiating heat, and secondly of absorbing radiant heat, the order will be the same in both cases. He further proved that the chief absorbing action of our atmosphere on non-luminous heat is due to its aqueous vapour. He applied his discovery to the explanation of many meteorological facts: *e.g.* the great daily range of the thermometer in dry climates; the production of frost at night in the Sahara; the cold in the table-lands of Asia, &c.

He discovered also the means of separating the invisible from the visible radiations, and proved that in the case of the electric light the former is no less than eight times as powerful as the latter. He also made the daring experiment of placing his eye at a focus of dark rays capable of heating platinum to redness.

Since 1866 his attention has been largely occupied in examining the action of heat of high refrangibility (instead of low), as an explorer of the molecular condition of matter

In this investigation one obstacle to be overcome was the presence of the floating matter in the air. The processes of removal of these particles became the occasion of an independent research, branching out into various channels; on the one hand, it dealt with the very practical problem of the preservation of life among firemen exposed to heated smoke; and, on the other, it approached the recondite question of spontaneous generation.

He subjected the compound vapours of various substances to the action of a concentrated beam of light. The vapours were decomposed, and non-volatile products were formed. The decompositions always began with a blue cloud, which discharged perfectly polarised light at right angles to the beam. This suggested to him the origin of the blue colour of the sky; and as it showed the extraordinary amount of light that may be scattered by cloudy matter of extreme tenuity, he considered that it might be regarded as a suggestion towards explaining the nature of a comet's tail.

[The lecturer then exhibited the polarisation of light scattered by small particles suspended in the medium traversed by a beam from the electric lamp, employing for the purpose the chromatic effects due to the circular porlarisation of quartz.]

His volume of contributions to molecular physics in the domain of radiant heat, which contains only his original investigations on this subject, would alone suffice to show what is doing in the laboratory of our Institution.

If we compare him to Faraday at the same time of life, he has still many years of intellectual energy, the conversion of which into its scientific equivalent may, perhaps, be effected within these walls.

No one has regretted the destruction of the laboratory of Davy and of Faraday more than Prof. Tyndall. He almost prayed for the preservation of the place where their discoveries had been made; but as soon as he saw that in our struggle for existence such material aids as improved buildings would conduce alike to the progress of science and to the permanence of the Institution, he withdrew his objections, and threw all his powers into making the new laboratories as perfect as possible for the good of his successors.

I add a few words on the reasons which led the managers to recommend the rebuilding of our laboratories, and the consequent demolition of the place where the great discoveries that I have touched upon were made. In the opinion of those best qualified to judge, our chemical laboratory was badly ventilated, badly lighted, badly drained, and quite unfit to be occupied for many hours daily. It was probably the very worst, and certainly all but the worst chemical laboratory in London; and compared with more modern ones both at home and abroad, it was nowhere. The physical laboratory had remained for nearly seventy years in its original state. At first it was said to be equal to any laboratory; but then there were hardly any in existence in this country; and during the last few years such splendid edifices have arisen in London, in Oxford, in Cambridge, in Manchester and in Glasgow, and elsewhere, that the laboratory of Davy, of Faraday, and of Tyndall was much inferior to the private laboratories of the professors who carry on their course of instruction in public rooms of still greater size and extent of resource. The main purpose of our laboratories is research, and instead of offering by their excellence an inducement to professors to come and to stay, the one was a makeshift, the other a noble relic. Neither afforded facilities which were not offered in a larger measure elsewhere. And those only who know what is going on both at home and abroad can form an adequate idea of the competition which, in this respect alone, will prevail for a generation to come.

By the construction of new laboratories this material disadvantage will be removed. Future professors will have buildings constructed to aid research. Your liberality has spared no judicious expense; and, so far as the site would admit, our laboratories will be as perfect as the skill of our architect and the advice of our professors can make them.

In conclusion, let me lay before you what must still be done, in order that there may be earned for the new laboratories a reputation comparable with that which has hitherto proved both our glory and our support.

Our first and foremost object, beyond bricks and mortar, and money, and apparatus, must be to find a succession of professors of the old type; men who love research. But even Faraday would perhaps have been compelled to leave us, on account of the smallness of the sum which we could afford him, had not the endowment of the chemical chair, with 100*l.* a year, by the late Mr. Fuller, happily intervened. This timely endowment was probably a critical turning point in the history of the Institution. We may not easily find successors worthy of the great names who have gone before them; but we may do much toward preventing mistakes in future appointments by keeping steadily in view, that the promotion of natural knowledge is our main object; and that instruction and amusement, and brilliant audiences are all secondary to our principal purpose. Not that these subsidiary purposes are to be neglected or despised; and I, as your Treasurer, should be the last to undervalue them, but we feel confident that if the main purpose is effected, all the others will follow as a simple sequence.

Secondly, when we have found professors of the type that I have described, our next need is that we may be able, from independent resources at the disposal of the Institution, to offer them a remuneration which, all things taken into account, shall be an equivalent to what they would receive elsewhere. So that neither Government appointments, nor University professorships, nor the liberality of mercantile men, should be able to lure them from the path of discovery, to tuition, to arts, or to manufactures.

The one act of wisdom, among the many aberrations of an eccentric member of Parliament, saved Faraday to us, and thereby, as seems probable, our Institution to the country. The liberality of a Hebrew toy-dealer in the East of London has made the rebuilding of our laboratories possible.

It is said that Mr. Fuller, the feebleness of whose constitution denied him at all other times and places the rest necessary for health, could always find repose and even quiet slumber amid the murmuring lectures of the Royal Institution; and that, in gratitude for the peaceful hours thus snatched from an otherwise restless life, he bequeathed to us his magnificent legacy of 10,000*l.* If this evening's discourse shall have ensured one such blissful hour to any of his audience, your lecturer's efforts will not have been altogether in vain. But to each such happy individual he would express the hope that, as you have resembled Mr. Fuller in your experience of life, so may you emulate him in your liberality at death. In short, I would conclude almost in the words of old Bishop Andrews: "Unum operæ meæ pretium abs te peto, hoc autem vehementer expeto, ut mei pecatoris meorumque in precibus interdum memor sis." Which being interpreted is: "For these my efforts I beg but one thing in return, and this I beg most earnestly, viz. that you will now and then remember me a sinner against your patience and forbearance in your prayers, and that you will also be mindful of our professorships in your wills."

The following Table of the principal items of original work done by our Professors, taken in connection with their long series of laboratory notes, forms a monument of the intellectual activity, the manual dexterity, and the persevering industry, developed in the laboratories of the Royal Institution:—

DAVY

1806	Chemical Agencies of Electricity.
1807	Decomposition of Potash.
1810	Chlorine.
1812	Discourse on Radiant or Ethereal Matter.
1813	Iodine.
1815–6	Researches on Fire-damp and Flame.
1817	The Safety Lamp.

FARADAY

1820	Alloys of Steel.
1821	History of Electro-magnetism.
,,	Magnetic Rotations.
1823	Liquefaction of Chlorine and other Gases.
1825–6	New Compounds of Carbon and Hydrogen.
1825–9	Manufacture of Optical Glass.
1831	Vibrating Surfaces.
,,	Magneto-Electricity.
1832	Terrestrial Magneto-Electric Induction
1833	Identity of Electricities.
1834	Electro-Chemical Decomposition.
,,	Electricity of the Voltaic Pile.
1835	The Extra Current,
1837–8	Frictional Electricity.
,,	Specific Inductive Capacity.
1845–8	Magnetisation of Light.
,,	Lines of Magnetic Force.
,,	Magnetic Condition of all Matter.
,,	Diamagnetism.
,,	Magne-Crystallic Action,
1849-50	Magnetism of Flame and Gases.
,,	Atmospheric Magnetism.
1856	Relations of Gold and other Metals to Light.
1860	The Regelation of Ice.

TYNDALL

1853	Transmission of Heat through Organic Substances.
1854	Vibrations due to Contact of Bodies at Different Temperatures.
1855	Researches on Diamagnetic Force.
1856	Slaty Cleavage.
1857–8	Physical Properties of Ice and Glaciers.
1859–63	Absorption and Radiation of Heat by Gases.
1865	Calorescence.
1866–7	Action of Heat of high Refrangibility.
1868–9	Formation of Clouds.
,,	Colour and Polarisation of the Sky.
1870	Smoke and Dust Respirator.

FRANKLAND

1863–6	Synthesis of Acids of the Lactic Series.
1863	Mercury-methyl, Mercury-ethyl, and Mercury-amyl.
1864	Transformation of Organo-Mercury Compounds into Organo-Zinc Compounds.
,,	Combustion of Iron in Compressed Oxygen.
1865	Synthesis of Acids of the Acrylic Series.
,,	Synthesis of Fatty Acids.
1866	New Organic Radical Oxatyl.
1866	The Source of Muscular Power. Potential Energy in various kinds of Food.
1867	Source of Light in Flame. Effect of Pressure upon Luminosity of Flame.

THE GROWTH AND MIGRATIONS OF HELMINTHS

THE migration of helminths is one of the most interesting discoveries of modern zoology. These worms, generally parasitic, must often, in order to complete their growth, pass from one animal into another. This passage is of course accomplished by chance, as when one animal devours the whole or part of another, in which the helminth at a certain stage may be imbedded.

It is known that sheep attacked by sturdy, have in their brain a little worm, the *Cœnurus*. That worm when it is eaten by a dog is not digested by him, but grows in the intestine under the form of a peculiar tænia. It is also known that the tænia, or tape-worm, is generated by the growth of the human cysticercus of the pig. Very interesting researches have been made by several physiologists on that subject.

M. Villot has filled up many gaps in the history of the growth of the gordins. The gordins (Müller) are aquatic worms, whose body is very long and slim, the extremities being obtuse.

The form of the embryo is very different from that of the full-grown animal. It is a microscopic worm, cylindrical, not more than 0·209 mm. (0·00807 in.) in length, by 0·049 mm. (0·00177 in.) in breadth, and on which a head and a tail can be easily discerned. The head, as big as the body, is quite retractile; it has a triple crown of prickles, and is terminated in front by a kind of trunk or sucker, which is kept rigid by three strong needles that serve it as support; the head, in its motion of protraction and retraction, turns from its extremity to its base as a glove, and during that time the points of the prickles describe half a circle. When the head is out of the body, the point is directed backward: when it is retracted into the interior of the body the reverse takes place.

Numerous transverse folds exist on the body; they are close to one another and regular as real rings. The tail, not quite so broad as the body, is separated from it by a deep groove.

The great difference between those embryos that are free in the water and the worms which grow out of them after many migrations into the interior of several animals, deserves to be noticed. The embryo after leaving its egg for the water in which it must live, has little means of locomotion. Its tail, cylindrical and scarcely moveable, is useless to it for swimming, so that it may be driven by any current. It probably sticks to pebbles or to the roots or stems of aquatic plants, where it waits for the larvæ, whose parasite it is to become. The author has verified these statements by putting in the same vessel several embryos with larvæ of tipulars (*Corethra*, *Janipus*, *Chironomus*), and has seen the former encyst themselves in the insects. The worm penetrates with its cephalic prickles into those larvæ, the teguments of which have little power of resistance. It continues the operation, piercing through more and more, till the membranes get solidified around it and form a real cyst, shut up at the posterior post. It continues to penetrate the body of the larvæ, lengthening its cyst and proceeds.

Those cysts do not grow normally in the interior of insects as has been believed up to this time, but in certain fishes, and particularly in the loaches (*Cobitis barbatula*) and minnows (*Phoxinus lavis*). Fishes are generally very fond of the larvæ of insects, but most especially for the larvæ of Chironomus. It is precisely in those larvæ, as we have already seen, that the embryos of gordins encyst themselves. By swallowing them, the fish swallows at